

26p

N63-15235

NASA TN D-1776

NASA TN D-1776

Code-1



TECHNICAL NOTE

D-1776

AERODYNAMIC CHARACTERISTICS OF A FLEXIBLE-CANOPY
PARAGLIDER MODEL AT A MACH NUMBER OF 4.5 FOR
ANGLES OF ATTACK TO 360° AND SIDESLIP ANGLES
FROM 0° TO 90°

By Dewey E. Wornom and Robert T. Taylor

Langley Research Center
Langley Station, Hampton, Va.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON

April 1963

34p

554242

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TECHNICAL NOTE D-1776

AERODYNAMIC CHARACTERISTICS OF A FLEXIBLE-CANOPY
PARAGLIDER MODEL AT A MACH NUMBER OF 4.5 FOR
ANGLES OF ATTACK TO 360° AND SIDESLIP ANGLES
FROM 0° TO 90°

By Dewey E. Wornom and Robert T. Taylor

SUMMARY

15235

Force tests of a flexible-canopy paraglider model with a rigid frame have been conducted at a Mach number of 4.5 in the 2-foot hypersonic facility at the Langley Research Center. The aerodynamic characteristics were measured over an angle-of-attack range from 0° to 360° for sideslip angles from 0° to 90° at a Reynolds number of approximately 0.3×10^6 based on a model keel length of 5.75 inches. The variation of the aerodynamic coefficients with angle of attack at constant sideslip angles are presented with limited discussion.

For the moment reference center selected, the data at zero sideslip showed that longitudinal trim occurred at an angle of attack of 45.5° with a corresponding lift coefficient of 0.45 and a lift-drag ratio of 0.94. A maximum lift coefficient of 0.79 was obtained at an angle of attack of 68°. From visual observations of canopy action during the tests abrupt load reversal was noted to occur around an angle of attack of 180°.

INTRODUCTION

Application of the inflatable-paraglider concept as a recovery device for expended booster rockets and casings, manned spacecraft, and instrument payloads from orbital or suborbital flight has been considered by the Langley Research Center. Both experimental and analytical investigations have been conducted to evaluate the capabilities of the paraglider as such a device; results of these studies have been reported in references 1 to 6.

When recovery of instrumented space experiments using an uncontrolled paraglider is contemplated, it must be determined whether the paraglider will enter the atmosphere satisfactorily regardless of initial attitude. In addition to these studies of the paraglider dynamics on entry, a knowledge of aerodynamic heating and of loads is required. Definition of the static aerodynamic characteristics of the flight vehicle is a first step in any such study.

The purpose of this present investigation was to obtain the static aerodynamic characteristics of a proposed 0.0472-scale paraglider configuration, designed for recovery of an instrument package. Force tests of the paraglider model with a flexible canopy on a rigid frame were conducted at a Mach number of 4.5 up to an angle of attack of 360° for sideslip angles from 0° to 90° .

SYMBOLS

The forces and moments are referred to the body axis system. (See fig. 1.) In addition, lift and drag are also presented at zero sideslip. The moment reference center was located 58.33 percent of the theoretical model length aft of the intersection of the center lines of the leading-edge tubes and 50 percent of the theoretical model length below the center line of the keel tube. (See fig. 2.)

b span of canopy, 8.49 in.

c_A axial-force coefficient, $\frac{\text{Axial force}}{qS}$

c_D drag coefficient, $\frac{\text{Drag}}{qS}$

c_L lift coefficient, $\frac{\text{Lift}}{qS}$

c_N normal-force coefficient, $\frac{\text{Normal force}}{qS}$

c_m pitching-moment coefficient,
 $\frac{\text{Pitching moment about moment reference center}}{qSl}$

c_n yawing-moment coefficient,
 $\frac{\text{Yawing moment about moment reference center}}{qSb}$

c_Y side-force coefficient, $\frac{\text{Side force}}{qS}$

c_l rolling-moment coefficient,
 $\frac{\text{Rolling moment about moment reference center}}{qSb}$

l theoretical length of model, 6.00 in.

L/D lift-drag ratio

M free-stream Mach number

- q free-stream dynamic pressure, lb/sq ft
 S canopy area, $bl/2$, 0.177 sq ft
 α angle of attack, deg
 β angle of sideslip, deg
 γ vertical angular displacement of model support arm relative to tunnel center line, deg (see fig. 3)
 ϕ lateral angular displacement of model support arm relative to vertical plane through tunnel center line, deg (see fig. 3)

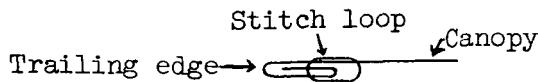
APPARATUS AND MODEL

The investigation was conducted in the 2-foot hypersonic facility at the Langley Research Center. This facility is a continuous-flow low-density variable Mach number tunnel. A description of this facility is given in reference 7.

A schematic diagram of the model support system is shown in figure 3 and photographs of the model installed in the tunnel are presented as figure 4. Fixed values of ϕ were obtained by inserting angled adapters in the model support arm and γ was varied by revolving the rotating side plate. This support system maintained the model in the center of the tunnel over the complete angle ranges of the investigation.

For the model forward condition the model support arm entered the model at the base of the keel tube (fig. 4(a)) and for the model reversed condition the model support arm entered at the nose of the model with a semispherical plug being inserted in the base of the keel tube (fig. 4(b)). Since considerable difficulty was experienced in maintaining an undamaged canopy, two interchangeable models were used to expedite the tests. Extreme care was exercised in attaching the replacement canopies to the leading-edge and keel tubes of the two models to assure identical canopy shape since any difference would alter the forces and moments measured.

Dimensional details of the 0.0472-scale model, including canopy development, are given in figure 2. The leading-edge, keel, and payload support tubes were integrally molded of plastic with metal inserts for strength. The canopy, made of 3.8-ounce dacron sailcloth, was attached to the leading-edge tubes with cement and held securely on top of the keel tube by a 0.05-inch-thick metal plate. The trailing edge of the canopy was folded twice and stitched for strength as shown in sketch 1.



Sketch 1

Several differences between the model and a full-scale paraglider exist: The full-scale vehicle would have shroud lines from the leading-edge tube to the bottom of the payload support tube, whereas on the model for these tests the lines were not present; the keel tube of the full-scale vehicle would be tapered like the leading-edge tubes; and, since a balance and model support arm had to enter the base of the model keel tube, it was necessary to make this tube a constant diameter.

TESTS, MEASUREMENTS, AND ACCURACY

Tests were conducted at a Mach number of 4.5 with a stagnation pressure of about 2,120 pounds per square foot absolute, a stagnation temperature of about 300° F, and a Reynolds number of approximately 0.3×10^6 based on a model keel length of 5.75 inches.

To obtain the angle-of-attack range from 0° to 360° , the model support arm was varied from $\gamma = -90^{\circ}$ (or 270°) to 90° with the model facing forward (fig. 4(a)) and then facing rearward (fig. 4(b)). To obtain the sideslip range from 0° to 90° , values of ϕ of 0° , 10° , 30° , 60° , 87° , and 90° were used for both model forward and model reversed on the support system. The actual angles of attack and sideslip were computed from the set values of γ and ϕ by the following equations:

$$\alpha = \tan^{-1}\left(\frac{\tan \gamma}{\cos \phi}\right)$$

$$\beta = \sin^{-1}(\sin \phi \cos \gamma)$$

Forces and moments were measured by an internally cooled (water) six-component electrical strain-gage balance mounted within the keel tube of the model. The measured coefficients are estimated to be accurate within the following limits:

| | | |
|-------|-------|-------------|
| C_N | | ± 0.030 |
| C_A | | ± 0.010 |
| C_m | | ± 0.015 |
| C_l | | ± 0.001 |
| C_n | | ± 0.010 |
| C_Y | | ± 0.025 |

Angular measurements were corrected for balance and model support deflections under load. The angles of attack and sideslip were estimated to be within $\pm 0.2^{\circ}$.

Calibrations of the tunnel test section indicate that local deviations from the average free-stream Mach number in the region of the model were of the order of ± 0.03 . The average free-stream Mach number was held to within ± 0.02 of the nominal value of 4.5.

The effects of the presence of the model support system were not determined during these tests and no corrections have been applied to the presented data to account for support interference. The data have not been corrected for base or balance-chamber pressure.

RESULTS AND DISCUSSION

Aerodynamic Data

The basic data for a Mach number of 4.5 are presented in table I. The discrepancies between overlapping data in these tables may be due either to the difference in support interference resulting from reversing the model on the model support arm or to the possible differences in canopy shape resulting from replacing canopies on the models or to both.

The basic data of table I were cross-plotted to obtain the variation of the force and moment coefficients with angle of attack at constant values of sideslip angle. The results of the cross-plotting are presented in figure 5. Because of the manner in which the variations in angle of attack and sideslip angle were accomplished by the model support system and because of the number of test points taken over the large angle range of these tests, there were areas of insufficient data points to define the cross-plotted data. These insufficiently defined areas are indicated by the dashed lines in figure 5; however, data listed in table I(f) fully define the force and moment coefficients at $\alpha = 90^\circ$ and 270° . The discontinuity of the curves at an angle of attack of 180° coincides with the observed abrupt reversal of canopy loading that occurred approximately at that point. Since this reversal of loading was damaging to the canopy, no attempt was made to define the actual angle of attack where the reversal occurred.

The longitudinal aerodynamic characteristics of the paraglider model are presented in figure 6. For the moment reference center selected the model was longitudinally stable at angles of attack greater than 20° . Longitudinal trim occurred at an angle of attack of 45.5° ($C_L = 0.45$) with a corresponding lift-drag ratio of 0.94, which was essentially the maximum value obtainable. A maximum lift coefficient of approximately 0.79 was reached at an angle of attack of around 68° .

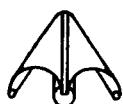
Canopy Action

Visual observation of the canopy during the tests showed that at 0° angles of attack and sideslip the canopy lay between the leading-edge and keel tubes and began to fill out slowly as the angle of attack was increased. (See sketch 2.) At $\alpha = 20^\circ$ and up to 20.5° the canopy appeared to be completely



$\alpha = 0^\circ$

Looking
upstream



$\alpha \approx 20^\circ$

Sketch 2

filled out but the trailing edge fluttered violently. At higher angles of attack the canopy became steady and completely loaded positively. The canopy action around $\alpha = 20^\circ$ occurred without hysteresis and is related to the longitudinal aerodynamic characteristics of the model in figure 6. The smooth variation of lift coefficient with angle of attack around $\alpha = 20^\circ$ indicates that there was no sudden loading of the canopy. The change in slope of the pitching-moment-coefficient curve from an unstable slope below $\alpha = 20^\circ$ to a stable slope above this angle of attack shows that the canopy loading is contributing a stabilizing force to the complete model. Above $\alpha = 90^\circ$ the complete exposure of the canopy trailing edge to the oncoming airstream caused the trailing edge to buckle with ripples running parallel to the trailing edge. This condition became more severe as the angle of attack was increased to 180° . It was also noted during the tests that for the angle-of-attack range from 90° to 180° extreme stress appeared to be imposed upon the canopy near the nose of the model between the leading-edge and keel tubes, which was caused by the oncoming airstream being trapped in this region. As previously mentioned, canopy load reversal occurred around $\alpha = 180^\circ$ with the canopy being fully loaded and smooth until it unloaded gently at $\alpha = 330^\circ$; the canopy then slowly collapsed to the previous condition stated for $\alpha = 0^\circ$.

In general, the effect of sideslip on the canopy action was to require higher angles of attack to completely load the canopy in a symmetrical shape due to the cross flow of air. For some model attitudes this cross flow caused the upstream panel of the canopy to flutter violently and occasionally caused the trailing-edge stitching to unravel.

CONCLUSIONS

Results of force tests of a flexible-canopy paraglider model at a Mach number of 4.5 up to an angle of attack of 360° for sideslip angles from 0° to 90° indicate the following conclusions:

1. For the moment center selected longitudinal trim occurred at an angle of attack of 45.5° with a corresponding lift coefficient of 0.45 and a lift-drag ratio of 0.94.
2. A maximum lift coefficient of approximately 0.79 occurred at an angle of attack of around 68° .
3. Abrupt canopy load reversal was noted to occur around an angle of attack of 180° .

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., January 28, 1963.

REFERENCES

1. Rogallo, Francis M., Lowry, John G., Croom, Delwin R., and Taylor, Robert T.: Preliminary Investigation of a Paraglider. NASA TN D-443, 1960.
2. Fournier, Paul G., and Bell, B. Ann: Low Subsonic Pressure Distributions on Three Rigid Wings Simulating Paragliders With Varied Canopy Curvature and Leading-Edge Sweep. NASA TN D-983, 1961.
3. Taylor, Robert T.: Wind-Tunnel Investigation of Paraglider Models at Supersonic Speeds. NASA TN D-985, 1961.
4. Hatch, Howard G., Jr., and McGowan, William A.: An Analytical Investigation of the Loads, Temperatures, and Ranges Obtained During the Recovery of Rocket Boosters by Means of a Parawing. NASA TN D-1003, 1962.
5. Fournier, Paul G., and Bell, B. Ann: Transonic Pressure Distributions On Three Rigid Wings Simulating Paragliders With Varied Canopy Curvature and Leading-Edge Sweep. NASA TN D-1009, 1962.
6. Penland, Jim A.: A Study of the Aerodynamic Characteristics of a Fixed Geometry Paraglider Configuration and Three Canopies With Simulated Variable Canopy Inflation at a Mach Number of 6.6. NASA TN D-1022, 1962.
7. Stokes, George M.: Description of a 2-Foot Hypersonic Facility at the Langley Research Center. NASA TN D-939, 1961.

TABLE I.- BASIC AERODYNAMIC DATA AT $M = 4.5$ (a) $\phi = 0^\circ$

| α , deg | β , deg | C_N | C_A | C_m | C_l | C_n | C_Y |
|----------------|---------------|-------|-------|--------|-------|-------|-------|
| Model forward | | | | | | | |
| 2.4 | 0.0 | 0.02 | 0.18 | 0.062 | 0.002 | -0.00 | 0.007 |
| 5.0 | .0 | .04 | .18 | .064 | .002 | -.00 | .008 |
| 7.5 | .0 | .05 | .18 | .067 | .001 | -.00 | .006 |
| 10.0 | .0 | .07 | .18 | .070 | .001 | -.00 | .004 |
| 15.0 | .0 | .11 | .19 | .077 | -.001 | -.00 | -.002 |
| 20.0 | .0 | .16 | .18 | .078 | .000 | -.00 | .002 |
| 25.1 | .0 | .22 | .17 | .073 | .000 | -.00 | .002 |
| 30.1 | .0 | .31 | .15 | .067 | .000 | -.00 | -.000 |
| 35.2 | .0 | .40 | .11 | .049 | -.005 | -.00 | -.012 |
| 40.2 | .0 | .53 | .08 | .032 | -.001 | -.00 | -.004 |
| 45.3 | .0 | .65 | .01 | -.002 | -.006 | -.00 | -.014 |
| 50.4 | .0 | .80 | -.03 | -.028 | -.005 | -.00 | -.010 |
| 55.4 | .0 | .94 | -.14 | -.085 | -.011 | -.00 | -.025 |
| 60.5 | .0 | 1.07 | -.23 | -.128 | -.012 | -.00 | -.026 |
| 70.6 | .0 | 1.29 | -.38 | -.179 | -.012 | -.00 | -.023 |
| 80.7 | .0 | 1.32 | -.49 | -.229 | -.018 | -.00 | -.035 |
| 90.8 | .0 | 1.34 | -.51 | -.195 | -.024 | -.02 | .005 |
| Model reversed | | | | | | | |
| 88.9 | 0.0 | 1.43 | -0.57 | -0.251 | 0.007 | -0.01 | 0.050 |
| 109.2 | .0 | .86 | -.34 | -.271 | -.010 | -.00 | .009 |
| 128.9 | .0 | 1.25 | -.74 | -.456 | -.002 | .00 | -.013 |
| 139.0 | .0 | 1.11 | -.68 | -.402 | .008 | .00 | .018 |
| 149.1 | .0 | 1.01 | -.68 | -.402 | .008 | .00 | .016 |
| 159.2 | .0 | .88 | -.68 | -.390 | .005 | -.00 | .017 |
| 169.4 | .0 | .72 | -.64 | -.352 | .003 | -.00 | .020 |
| 179.5 | .0 | .55 | -.58 | -.302 | .001 | -.00 | .025 |
| 190.3 | .0 | -.45 | -.36 | -.150 | .001 | .00 | .005 |
| 200.6 | .0 | -.77 | -.41 | -.172 | -.001 | .00 | .003 |
| 210.8 | .0 | -1.02 | -.44 | -.182 | -.003 | .00 | -.000 |
| 220.9 | .0 | -1.11 | -.42 | -.143 | -.003 | .00 | .002 |
| 230.9 | .0 | -1.20 | -.39 | -.141 | -.005 | .00 | .002 |
| 251.0 | .0 | -1.34 | -.34 | -.149 | -.008 | .00 | -.009 |
| 271.0 | .0 | -1.39 | -.29 | -.164 | -.008 | .00 | -.007 |
| Model forward | | | | | | | |
| 269.3 | 0.0 | -1.35 | -0.27 | -0.145 | 0.002 | -0.00 | 0.003 |
| 279.2 | .0 | -1.35 | -.23 | -.142 | .002 | -.00 | .004 |
| 289.2 | .0 | -1.32 | -.19 | -.131 | .003 | -.00 | .006 |
| 299.3 | .0 | -1.24 | -.13 | -.081 | .002 | -.00 | .004 |
| 309.5 | .0 | -.89 | -.03 | -.033 | .001 | -.00 | .002 |
| 319.6 | .0 | -.56 | .05 | .004 | .000 | -.00 | .001 |
| 329.8 | .0 | -.33 | .09 | .018 | .000 | -.00 | .003 |
| 334.8 | .0 | -.22 | .11 | .028 | -.000 | -.00 | .000 |
| 349.9 | .0 | -.05 | .14 | .039 | -.001 | -.00 | -.000 |
| 352.4 | .0 | -.00 | .17 | .055 | -.001 | -.00 | -.001 |
| 354.9 | .0 | -.01 | .15 | .045 | -.000 | -.00 | .001 |
| 357.4 | .0 | .01 | .16 | .048 | -.002 | -.00 | -.002 |
| 359.9 | .0 | .01 | .18 | .060 | .003 | -.00 | .009 |

TABLE I.- BASIC AERODYNAMIC DATA AT $M = 4.5$ - Continued(b) $\phi = 10^\circ$

| α , deg | β , deg | C_N | C_A | C_m | C_l | C_n | C_Y |
|----------------|---------------|-------|-------|--------|--------|-------|--------|
| Model forward | | | | | | | |
| 5.0 | 9.9 | 0.04 | 0.19 | 0.067 | -0.017 | 0.00 | -0.060 |
| 7.6 | 9.9 | .05 | .19 | .069 | -.019 | .00 | -.061 |
| 10.1 | 9.8 | .07 | .19 | .072 | -.019 | .00 | -.060 |
| 12.7 | 9.7 | .08 | .19 | .075 | -.020 | .00 | -.062 |
| 15.2 | 9.6 | .10 | .19 | .076 | -.021 | .00 | -.064 |
| 17.8 | 9.5 | .13 | .19 | .082 | -.025 | .00 | -.072 |
| 20.3 | 9.3 | .16 | .19 | .084 | -.026 | .00 | -.074 |
| 25.4 | 9.0 | .22 | .18 | .079 | -.026 | .00 | -.074 |
| 30.5 | 8.6 | .31 | .15 | .070 | -.028 | .00 | -.078 |
| 35.6 | 8.1 | .39 | .12 | .059 | -.032 | .00 | -.084 |
| 40.7 | 7.6 | .52 | .08 | .037 | -.035 | .00 | -.088 |
| 50.8 | 6.3 | .79 | -.03 | -.024 | -.042 | .00 | -.097 |
| 60.9 | 4.8 | 1.08 | -.22 | -.109 | -.045 | .00 | -.102 |
| 70.9 | 3.2 | 1.27 | -.37 | -.161 | -.033 | .00 | -.072 |
| 80.8 | 1.6 | 1.31 | -.46 | -.199 | -.019 | .00 | -.038 |
| 90.8 | -.1 | 1.30 | -.44 | -.136 | .002 | .00 | -.024 |
| Model reversed | | | | | | | |
| 89.0 | -0.1 | 1.40 | -0.53 | -0.219 | 0.002 | -0.01 | 0.055 |
| 99.2 | 1.6 | .97 | -.29 | -.091 | -.033 | -.01 | .007 |
| 109.0 | 3.2 | .85 | -.32 | -.261 | -.049 | -.01 | -.018 |
| 118.6 | 4.8 | 1.18 | -.56 | -.412 | -.058 | -.00 | -.091 |
| 128.5 | 6.2 | 1.25 | -.65 | -.410 | -.023 | .01 | -.080 |
| 138.7 | 7.5 | 1.03 | -.61 | -.353 | -.029 | .00 | -.048 |
| 148.9 | 8.5 | .85 | -.57 | -.323 | -.045 | .00 | -.060 |
| 159.1 | 9.3 | .71 | -.56 | -.314 | -.051 | .00 | -.057 |
| 164.2 | 9.6 | .65 | -.55 | -.304 | -.049 | .00 | -.048 |
| 190.5 | 9.8 | -.46 | -.30 | -.117 | -.025 | .01 | -.085 |
| 200.8 | 9.3 | -.73 | -.34 | -.133 | -.025 | .01 | -.088 |
| 211.1 | 8.5 | -.95 | -.38 | -.139 | -.030 | .01 | -.096 |
| 221.2 | 7.5 | -1.04 | -.37 | -.114 | -.031 | .01 | -.102 |
| 231.3 | 6.2 | -1.15 | -.33 | -.124 | -.019 | .00 | -.060 |
| 241.3 | 4.8 | -1.27 | -.33 | -.132 | -.011 | .00 | -.031 |
| 251.2 | 3.2 | -1.30 | -.30 | -.141 | -.009 | .00 | -.025 |
| 261.1 | 1.5 | -1.33 | -.28 | -.148 | -.006 | .00 | -.016 |
| 271.0 | -.1 | -1.34 | -.25 | -.149 | -.004 | .00 | -.005 |
| Model forward | | | | | | | |
| 269.3 | -0.1 | -1.36 | -0.27 | -0.162 | 0.009 | -0.00 | 0.011 |
| 279.1 | 1.6 | -1.34 | -.23 | -.160 | .008 | -.00 | .002 |
| 288.9 | 3.2 | -1.30 | -.19 | -.143 | .005 | -.00 | -.009 |
| 298.9 | 4.8 | -1.20 | -.14 | -.102 | -.002 | -.00 | -.036 |
| 309.0 | 6.3 | -.86 | -.03 | -.050 | -.014 | .00 | -.068 |
| 319.2 | 7.6 | -.56 | .03 | -.013 | -.018 | .00 | -.076 |
| 324.3 | 8.1 | -.44 | .06 | -.000 | -.018 | .00 | -.076 |
| 329.4 | 8.6 | -.32 | .08 | .010 | -.018 | .00 | -.073 |
| 334.5 | 9.0 | -.23 | .08 | .007 | -.017 | .00 | -.068 |
| 339.6 | 9.3 | -.15 | .12 | .024 | -.016 | .00 | -.065 |
| 342.1 | 9.5 | -.12 | .12 | .028 | -.016 | .00 | -.063 |
| 344.7 | 9.6 | -.09 | .13 | .030 | -.016 | -.00 | -.062 |
| 347.2 | 9.7 | -.07 | .14 | .034 | -.015 | -.00 | -.061 |
| 349.7 | 9.8 | -.05 | .15 | .038 | -.015 | .00 | -.060 |
| 352.3 | 9.9 | -.05 | .16 | .048 | -.014 | .00 | -.061 |
| 354.8 | 9.9 | -.03 | .16 | .050 | -.015 | .00 | -.062 |
| 357.4 | 9.9 | -.00 | .16 | .050 | -.018 | -.00 | -.062 |
| 359.9 | 10.0 | .00 | .17 | .054 | -.018 | .00 | -.061 |

TABLE I.- BASIC AERODYNAMIC DATA AT M = 4.5 - Continued

(c) $\phi = 30^\circ$

| α , deg | β , deg | C_N | C_A | C_m | C_l | C_n | C_Y |
|-----------------------|---------------|---------|-------|--------|--------|-------|--------|
| Model forward | | | | | | | |
| 2.8 | 30.1 | 0.04 | 0.18 | 0.066 | -0.046 | 0.00 | -0.169 |
| 5.7 | 30.0 | .06 | .19 | .073 | -.050 | .00 | -.177 |
| 8.6 | 29.8 | .07 | .19 | .075 | -.054 | .00 | -.185 |
| 11.5 | 29.6 | .09 | .19 | .080 | -.058 | .00 | -.190 |
| 14.4 | 29.3 | .11 | .20 | .085 | -.062 | .00 | -.196 |
| 17.2 | 29.0 | .13 | .20 | .086 | -.068 | .00 | -.206 |
| 20.0 | 28.6 | .16 | .19 | .087 | -.073 | .00 | -.216 |
| 22.8 | 28.2 | .19 | .19 | .086 | -.077 | .00 | -.225 |
| 28.4 | 27.1 | .26 | .16 | .076 | -.084 | .01 | -.237 |
| 33.8 | 25.8 | .35 | .13 | .063 | -.091 | .01 | -.253 |
| 39.1 | 24.4 | .45 | .09 | .046 | -.098 | .01 | -.265 |
| 44.3 | 22.8 | .56 | .04 | .022 | -.108 | .01 | -.283 |
| 54.3 | 19.1 | .84 | -.04 | -.027 | -.123 | .01 | -.303 |
| 63.8 | 14.9 | 1.13 | -.26 | -.127 | -.108 | .01 | -.263 |
| 73.0 | 10.3 | 1.22 | -.39 | -.159 | -.075 | .01 | -.177 |
| 81.8 | 5.4 | 1.28 | -.48 | -.199 | -.048 | .00 | -.106 |
| 90.5 | .4 | 1.26 | -.43 | -.128 | -.003 | .00 | -.027 |
| Model reversed | | | | | | | |
| 91.4 | 1.8 | 1.42 | -0.56 | -0.240 | -0.033 | -0.02 | 0.034 |
| 106.9 | 10.3 | 1.01 | -.39 | -.258 | -.130 | -.02 | -.114 |
| 125.4 | 19.2 | 1.16 | -.57 | -.346 | -.072 | .01 | -.155 |
| 135.4 | 23.1 | 1.03 | -.58 | -.354 | -.103 | .04 | -.253 |
| 145.9 | 26.1 | .83 | -.52 | -.317 | -.104 | .02 | -.233 |
| 156.9 | 28.3 | .68 | -.48 | -.277 | -.111 | .01 | -.235 |
| 168.3 | 29.8 | .54 | -.44 | -.242 | -.116 | .03 | -.262 |
| 180.0 | 30.2 | -.02 | -.21 | -.082 | -.043 | .04 | -.179 |
| 191.6 | 29.7 | -.37 | -.21 | -.073 | -.059 | .02 | -.213 |
| 203.0 | 28.3 | -.62 | -.24 | -.067 | -.050 | .03 | -.208 |
| 214.0 | 26.0 | -.80 | -.25 | -.062 | -.040 | .02 | -.189 |
| 224.5 | 22.9 | -.95 | -.27 | -.081 | -.036 | .02 | -.160 |
| 234.5 | 19.2 | -.14 | -.27 | -.083 | -.037 | .02 | -.140 |
| 253.1 | 10.4 | -.136 | -.28 | -.119 | -.015 | .00 | -.070 |
| 268.5 | 1.8 | -.142 | -.25 | -.137 | -.005 | -.00 | -.023 |
| Model forward | | | | | | | |
| 269.5 | 0.5 | -1.3170 | -0.25 | -0.160 | 0.009 | 0.00 | 0.012 |
| 278.1 | 5.4 | -1.2947 | -.21 | -.153 | .005 | .00 | -.015 |
| 286.9 | 10.3 | -1.2400 | -.17 | -.138 | -.002 | .00 | -.055 |
| 296.1 | 14.8 | -1.1143 | -.12 | -.107 | -.021 | .00 | -.118 |
| 305.6 | 19.0 | -.8480 | -.02 | -.047 | -.043 | .00 | -.189 |
| 315.6 | 22.8 | -.5762 | .06 | -.004 | -.057 | .00 | -.223 |
| 320.8 | 24.4 | -.4544 | .09 | .011 | -.056 | .00 | -.215 |
| 326.1 | 25.8 | -.3531 | .11 | .024 | -.052 | .00 | -.200 |
| 331.5 | 27.1 | -.2669 | .13 | .035 | -.046 | .00 | -.185 |
| 337.1 | 28.2 | -.1929 | .15 | .043 | -.045 | .00 | -.180 |
| 339.9 | 28.6 | -.1588 | .16 | .047 | -.046 | .00 | -.182 |
| 342.7 | 29.0 | -.1275 | .17 | .052 | -.044 | .00 | -.174 |
| 345.6 | 29.3 | -.1036 | .18 | .056 | -.044 | .00 | -.173 |
| 348.4 | 29.6 | -.0900 | .18 | .061 | -.044 | .00 | -.174 |
| 351.3 | 29.8 | -.0533 | .18 | .058 | -.047 | .00 | -.171 |
| 354.2 | 30.0 | -.0339 | .19 | .062 | -.046 | .00 | -.167 |
| 357.1 | 30.1 | -.0171 | .19 | .067 | -.048 | .00 | -.170 |
| 360.0 | 30.1 | .0066 | .20 | .069 | -.050 | .00 | -.174 |

TABLE I.-- BASIC AERODYNAMIC DATA AT $M = 4.5$ - Continued(d) $\phi = 60^\circ$

| α , deg | β , deg | C_N | C_A | C_m | C_l | C_n | C_Y |
|----------------|---------------|-------|-------|--------|--------|-------|---------|
| Model forward | | | | | | | |
| 0.0 | 60.2 | -0.00 | 0.15 | 0.063 | -0.068 | 0.00 | -0.2564 |
| 5.0 | 60.0 | .05 | .15 | .061 | -.065 | .00 | -.2483 |
| 9.9 | 59.8 | .04 | .15 | .064 | -.073 | .00 | -.2656 |
| 14.8 | 59.3 | .07 | .15 | .065 | -.079 | .00 | -.2766 |
| 19.5 | 58.7 | .10 | .15 | .066 | -.085 | .00 | -.2902 |
| 23.9 | 57.9 | .13 | .14 | .065 | -.090 | .00 | -.3006 |
| 28.2 | 57.0 | .16 | .13 | .062 | -.096 | .01 | -.3178 |
| 32.5 | 55.9 | .21 | .15 | .059 | -.103 | .01 | -.3314 |
| 36.1 | 54.7 | .25 | .11 | .054 | -.112 | .01 | -.3503 |
| 43.1 | 52.0 | .35 | .08 | .037 | -.131 | .01 | -.3834 |
| 49.2 | 48.9 | .46 | .04 | .018 | -.153 | .01 | -.4281 |
| 54.6 | 45.6 | .57 | -.00 | .001 | -.177 | .01 | -.4725 |
| 59.3 | 42.0 | .67 | -.06 | -.023 | -.196 | .01 | -.4991 |
| 67.3 | 34.3 | .89 | -.20 | -.086 | -.177 | .00 | -.4252 |
| 73.9 | 26.2 | 1.09 | -.55 | -.150 | -.135 | .00 | -.3276 |
| 79.7 | 17.9 | 1.26 | -.42 | -.194 | -.103 | .00 | -.2361 |
| 85.0 | 9.3 | 1.24 | -.45 | -.177 | -.088 | -.01 | -.1556 |
| 90.0 | .7 | 1.20 | -.40 | -.109 | -.020 | -.01 | -.0076 |
| Model reversed | | | | | | | |
| 91.2 | 3.1 | 1.38 | -0.47 | -0.222 | -0.058 | -0.01 | -0.0865 |
| 94.9 | 9.5 | 1.22 | -.46 | -.209 | -.136 | -.01 | -.2046 |
| 100.2 | 18.1 | 1.18 | -.46 | -.243 | -.122 | -.00 | -.2212 |
| 106.0 | 26.5 | 1.12 | -.48 | -.268 | -.130 | .01 | -.2623 |
| 112.7 | 34.6 | .94 | -.40 | -.219 | -.147 | .01 | -.3200 |
| 120.7 | 42.2 | .75 | -.33 | -.171 | -.140 | .01 | -.3149 |
| 125.5 | 45.7 | .66 | -.30 | -.155 | -.132 | .02 | -.3052 |
| 130.9 | 49.1 | .58 | -.28 | -.150 | -.128 | .02 | -.3028 |
| 137.0 | 52.2 | .52 | -.27 | -.145 | -.127 | .02 | -.3061 |
| 144.0 | 54.9 | .46 | -.25 | -.137 | -.130 | .03 | -.3187 |
| 147.8 | 56.1 | .42 | -.24 | -.128 | -.131 | .03 | -.3268 |
| 151.9 | 57.2 | .38 | -.22 | -.118 | -.133 | .03 | -.3352 |
| 156.2 | 58.1 | .33 | -.20 | -.108 | -.132 | .03 | -.3414 |
| 160.7 | 58.9 | .29 | -.18 | -.092 | -.127 | .05 | -.3573 |
| 165.3 | 59.5 | .24 | -.17 | -.081 | -.124 | .03 | -.3385 |
| 170.2 | 60.0 | .21 | -.16 | -.073 | -.122 | .03 | -.3384 |
| 174.8 | 60.1 | -.04 | -.03 | .001 | -.060 | .03 | -.2578 |
| 179.8 | 60.2 | -.10 | -.03 | .001 | -.058 | .03 | -.2584 |
| 184.8 | 60.2 | -.14 | -.04 | -.002 | -.058 | .03 | -.2611 |
| 189.7 | 59.9 | -.19 | -.04 | -.004 | -.058 | .03 | -.2660 |
| 194.5 | 59.5 | -.24 | -.05 | -.007 | -.059 | .03 | -.2747 |
| 199.2 | 58.9 | -.29 | -.06 | -.010 | -.060 | .02 | -.2832 |
| 203.7 | 58.1 | -.33 | -.07 | -.014 | -.060 | .03 | -.2921 |
| 208.0 | 57.2 | -.38 | -.07 | -.012 | -.062 | .02 | -.3036 |
| 212.0 | 56.1 | -.42 | -.08 | -.015 | -.062 | .03 | -.3088 |
| 215.9 | 54.9 | -.47 | -.09 | -.017 | -.066 | .03 | -.3246 |
| 222.8 | 52.2 | -.54 | -.10 | -.016 | -.059 | .03 | -.3082 |
| 229.0 | 49.1 | -.62 | -.10 | -.022 | -.055 | .02 | -.2896 |
| 234.3 | 45.8 | -.71 | -.12 | -.032 | -.055 | .02 | -.2758 |
| 239.1 | 42.2 | -.81 | -.14 | -.048 | -.053 | .02 | -.2568 |
| 247.1 | 34.6 | -1.00 | -.18 | -.076 | -.055 | .01 | -.2016 |
| 253.8 | 26.5 | -1.18 | -.21 | -.102 | -.029 | .01 | -.1543 |
| 259.6 | 18.2 | -1.30 | -.23 | -.117 | -.022 | .00 | -.1055 |
| 264.9 | 9.6 | -1.35 | -.24 | -.127 | -.013 | .00 | -.0595 |
| 268.7 | 3.1 | -1.36 | -.23 | -.128 | -.006 | -.00 | -.0206 |
| Model forward | | | | | | | |
| 270.0 | 0.6 | -1.30 | -.26 | -0.159 | 0.013 | -0.00 | 0.0343 |
| 275.0 | 9.3 | -.128 | -.24 | -.161 | .006 | -.00 | -.0136 |
| 280.3 | 17.9 | -.122 | -.21 | -.151 | -.008 | .00 | -.0791 |
| 286.0 | 26.2 | -.110 | -.16 | -.126 | -.026 | .00 | -.1546 |
| 292.7 | 34.3 | -.92 | -.09 | -.091 | -.049 | .00 | -.2435 |
| 300.7 | 42.0 | -.72 | -.02 | -.043 | -.080 | .01 | -.3366 |
| 305.5 | 45.6 | -.62 | -.00 | -.030 | -.086 | .01 | -.3447 |
| 310.8 | 48.9 | -.51 | .04 | .001 | -.084 | .01 | -.3293 |
| 316.9 | 52.0 | -.39 | .07 | .015 | -.078 | .00 | -.3105 |
| 323.9 | 54.7 | -.28 | .10 | .029 | -.073 | .00 | -.2974 |
| 327.7 | 55.9 | -.24 | .11 | .035 | -.072 | .00 | -.2892 |
| 331.8 | 57.0 | -.20 | .12 | .042 | -.069 | .00 | -.2811 |
| 336.1 | 57.9 | -.16 | .14 | .048 | -.065 | .00 | -.2679 |
| 340.6 | 58.7 | -.13 | .14 | .053 | -.064 | .00 | -.2599 |
| 345.2 | 59.3 | -.09 | .13 | .047 | -.062 | .00 | -.2514 |
| 350.1 | 59.8 | -.07 | .16 | .064 | -.061 | .00 | -.2456 |
| 355.0 | 60.1 | -.04 | .17 | .067 | -.065 | .00 | -.2503 |

TABLE I.- BASIC AERODYNAMIC DATA AT M = 4.5 - Continued

(e) $\phi = 87^\circ$

| α , deg | β , deg | C_N | C_A | C_m | C_l | C_n | C_Y |
|----------------|---------------|-------|-------|--------|--------|-------|--------|
| Model forward | | | | | | | |
| 0.0 | 87.0 | -0.01 | 0.04 | 0.020 | -0.059 | 0.01 | -0.235 |
| 40.7 | 86.1 | .02 | .03 | .019 | -.053 | .01 | -.239 |
| 59.8 | 84.2 | .03 | .03 | .015 | -.068 | .01 | -.252 |
| 68.9 | 81.9 | .06 | .02 | .014 | -.070 | .01 | -.259 |
| 74.0 | 79.6 | .10 | .02 | .013 | -.075 | .01 | -.271 |
| 77.1 | 77.1 | .14 | .01 | .010 | -.082 | .01 | -.287 |
| 79.3 | 74.7 | .18 | .00 | .003 | -.088 | .01 | -.302 |
| 80.9 | 72.2 | .24 | -.00 | -.001 | -.095 | .01 | -.318 |
| 82.1 | 69.8 | .30 | -.02 | -.008 | -.103 | .01 | -.333 |
| 83.9 | 64.8 | .43 | -.05 | -.027 | -.125 | .01 | -.375 |
| 85.0 | 59.8 | .55 | -.10 | -.043 | -.147 | .01 | -.407 |
| 85.9 | 54.9 | .69 | -.15 | -.071 | -.174 | .01 | -.447 |
| 86.6 | 49.9 | .80 | -.22 | -.106 | -.195 | .00 | -.470 |
| 87.6 | 59.9 | .96 | -.31 | -.165 | -.191 | .01 | -.415 |
| 88.3 | 29.9 | 1.11 | -.42 | -.218 | -.150 | .01 | -.319 |
| 88.9 | 19.9 | 1.20 | -.44 | -.225 | -.126 | .00 | -.234 |
| 89.5 | 9.9 | 1.22 | -.46 | -.198 | -.127 | -.02 | -.160 |
| 89.9 | 2.5 | 1.22 | -.43 | -.149 | -.053 | -.03 | -.012 |
| Model reversed | | | | | | | |
| 90.1 | 2.5 | 1.45 | -0.49 | -0.247 | -0.041 | 0.00 | -0.111 |
| 90.5 | 9.9 | 1.31 | -.39 | -.178 | -.095 | -.00 | -.197 |
| 91.0 | 19.9 | 1.24 | -.36 | -.181 | -.117 | .00 | -.233 |
| 91.6 | 29.9 | 1.13 | -.34 | -.176 | -.152 | .01 | -.339 |
| 92.2 | 39.9 | .98 | -.26 | -.135 | -.196 | .02 | -.447 |
| 93.2 | 49.9 | .82 | -.18 | -.086 | -.198 | .01 | -.482 |
| 93.8 | 54.9 | .72 | -.12 | -.057 | -.172 | .01 | -.447 |
| 94.7 | 59.8 | .59 | -.08 | -.037 | -.146 | .01 | -.405 |
| 95.8 | 64.8 | .46 | -.05 | -.019 | -.126 | .01 | -.372 |
| 97.5 | 69.8 | .33 | .00 | .005 | -.105 | .02 | -.332 |
| 98.7 | 72.2 | .27 | -.01 | -.004 | -.099 | .02 | -.322 |
| 100.3 | 74.7 | .22 | -.00 | .001 | -.095 | .02 | -.314 |
| 102.3 | 77.2 | .17 | .00 | .002 | -.089 | .02 | -.300 |
| 105.4 | 79.6 | .13 | .01 | .010 | -.085 | .02 | -.291 |
| 110.2 | 82.0 | .09 | .02 | .014 | -.085 | .02 | -.293 |
| 119.2 | 84.2 | .06 | .03 | .024 | -.075 | .02 | -.274 |
| 138.3 | 86.2 | .03 | .03 | .023 | -.071 | .02 | -.265 |
| 180.0 | 87.1 | -.00 | .03 | .019 | -.068 | .02 | -.259 |
| 221.5 | 86.2 | -.04 | .02 | .017 | -.065 | .02 | -.257 |
| 240.6 | 84.2 | -.07 | .02 | .016 | -.064 | .02 | -.254 |
| 249.4 | 81.9 | -.12 | .02 | .012 | -.063 | .01 | -.254 |
| 254.4 | 79.6 | -.15 | .00 | .006 | -.071 | .02 | -.273 |
| 257.5 | 77.2 | -.21 | .00 | .000 | -.077 | .02 | -.289 |
| 259.7 | 74.7 | -.26 | .00 | .000 | -.077 | .02 | -.295 |
| 261.2 | 72.2 | -.32 | -.00 | -.005 | -.082 | .02 | -.307 |
| 262.4 | 69.8 | -.37 | -.01 | -.011 | -.085 | .02 | -.325 |
| 264.0 | 64.8 | -.49 | -.04 | -.029 | -.091 | .02 | -.332 |
| 265.2 | 59.8 | -.60 | -.06 | -.042 | -.095 | .02 | -.342 |
| 266.0 | 54.9 | -.72 | -.08 | -.055 | -.089 | .02 | -.337 |
| 266.7 | 49.9 | -.82 | -.11 | -.066 | -.085 | .02 | -.334 |
| 267.6 | 39.9 | -1.00 | -.16 | -.091 | -.052 | .01 | -.258 |
| 268.3 | 29.9 | -1.17 | -.20 | -.113 | -.035 | .00 | -.180 |
| 268.9 | 19.9 | -1.30 | -.23 | -.128 | -.023 | .00 | -.112 |
| 269.5 | 9.9 | -1.35 | -.24 | -.133 | -.012 | -.00 | -.050 |
| 269.9 | 2.5 | -1.37 | -.24 | -.132 | -.007 | -.00 | -.012 |
| Model forward | | | | | | | |
| 270.1 | 2.5 | -1.38 | -0.28 | -0.146 | 0.000 | 0.00 | -0.004 |
| 270.5 | 9.9 | -1.35 | -.28 | -.145 | -.003 | .00 | -.039 |
| 271.0 | 19.9 | -1.29 | -.26 | -.138 | -.014 | .01 | -.097 |
| 271.6 | 29.9 | -1.15 | -.22 | -.122 | -.022 | .01 | -.156 |
| 272.4 | 39.9 | -.99 | -.17 | -.096 | -.040 | .01 | -.236 |
| 273.4 | 49.9 | -.81 | -.11 | -.068 | -.075 | .02 | -.319 |
| 274.1 | 54.9 | -.72 | -.08 | -.055 | -.082 | .02 | -.330 |
| 274.9 | 59.8 | -.60 | -.06 | -.041 | -.086 | .02 | -.331 |
| 276.1 | 64.8 | -.49 | -.04 | -.026 | -.088 | .02 | -.327 |
| 277.8 | 69.8 | -.37 | -.02 | -.012 | -.082 | .02 | -.311 |
| 279.0 | 72.2 | -.31 | -.01 | -.008 | -.077 | .01 | -.297 |
| 280.7 | 74.7 | -.26 | -.00 | -.003 | -.073 | .01 | -.283 |
| 282.8 | 77.1 | -.21 | .00 | .000 | -.067 | .01 | -.267 |
| 286.0 | 79.5 | -.17 | .01 | .005 | -.064 | .01 | -.256 |
| 291.0 | 81.9 | -.12 | .02 | .009 | -.059 | .01 | -.242 |
| 300.1 | 84.2 | -.09 | .03 | .014 | -.061 | .01 | -.243 |
| 319.3 | 86.1 | -.05 | .04 | .019 | -.059 | .01 | -.235 |

TABLE I.- BASIC AERODYNAMIC DATA AT $M = 4.5$ - Concluded $(f) \phi = 90^\circ$

| α , deg | β , deg | c_N | c_A | c_m | c_l | c_n | c_y |
|----------------|---------------|--------|-------|--------|--------|-------|--------|
| Model forward | | | | | | | |
| 90.0 | 0.0 | 1.15 | -0.38 | -0.096 | -0.003 | -0.00 | -0.023 |
| 90.0 | 10.0 | 1.20 | -.48 | -.178 | -.117 | -.05 | -.143 |
| 90.0 | 20.0 | 1.19 | -.45 | -.213 | -.153 | -.00 | -.253 |
| 90.0 | 30.0 | 1.10 | -.47 | -.221 | -.166 | .01 | -.356 |
| 90.1 | 40.0 | .95 | -.36 | -.172 | -.194 | .01 | -.437 |
| 90.1 | 50.0 | .79 | -.28 | -.123 | -.213 | .00 | -.512 |
| 90.3 | 55.0 | .71 | -.20 | -.082 | -.195 | .00 | -.496 |
| 90.3 | 60.0 | .58 | -.14 | -.049 | -.162 | .00 | -.442 |
| 90.3 | 65.0 | .46 | -.09 | -.034 | -.139 | .01 | -.410 |
| 90.4 | 70.0 | .33 | -.05 | -.015 | -.116 | .01 | -.365 |
| 90.4 | 72.5 | .27 | -.03 | -.010 | -.107 | .01 | -.347 |
| 90.5 | 75.0 | .21 | -.02 | -.007 | -.099 | .01 | -.328 |
| 90.5 | 77.5 | .16 | -.01 | -.003 | -.092 | .01 | -.315 |
| 90.6 | 80.0 | .12 | -.00 | -.000 | -.086 | .01 | -.300 |
| 90.8 | 82.5 | .09 | -.00 | -.001 | -.079 | .01 | -.286 |
| 91.1 | 85.0 | .05 | -.00 | -.005 | -.076 | .01 | -.279 |
| 92.2 | 87.5 | .02 | -.00 | -.007 | -.074 | .01 | -.272 |
| 0 to 360.0 | 90.0 | -.00 | .02 | .014 | -.068 | .01 | -.260 |
| 267.9 | 87.5 | -.02 | .02 | .014 | -.067 | .01 | -.253 |
| 268.9 | 85.0 | -.08 | .02 | .013 | -.059 | .01 | -.242 |
| 269.3 | 82.5 | -.11 | .02 | .008 | -.057 | .01 | -.241 |
| 269.5 | 80.0 | -.15 | .01 | .002 | -.061 | .01 | -.256 |
| 269.5 | 77.5 | -.19 | .00 | -.001 | -.065 | .01 | -.268 |
| 269.6 | 75.0 | -.24 | -.03 | -.019 | -.069 | .01 | -.281 |
| 269.7 | 72.5 | -.29 | -.01 | -.014 | -.074 | .01 | -.296 |
| 269.7 | 70.0 | -.35 | -.05 | -.031 | -.080 | .02 | -.315 |
| 269.7 | 65.0 | -.46 | -.04 | -.035 | -.087 | .02 | -.332 |
| 269.8 | 60.0 | -.56 | -.06 | -.054 | -.083 | .02 | -.327 |
| 269.8 | 55.0 | -.67 | -.09 | -.071 | -.082 | .01 | -.326 |
| 269.9 | 50.0 | -.76 | -.12 | -.086 | -.078 | .01 | -.324 |
| 269.9 | 40.0 | -.93 | -.17 | -.113 | -.047 | .01 | -.251 |
| 270.0 | 30.0 | -.1.08 | -.22 | -.143 | -.028 | .00 | -.170 |
| 270.0 | 20.0 | -.1.25 | -.26 | -.164 | -.014 | .00 | -.093 |
| 270.0 | 10.0 | -.1.29 | -.28 | -.170 | -.002 | .00 | -.020 |
| 270.0 | 0 | -.1.32 | -.29 | -.170 | -.011 | .00 | -.034 |

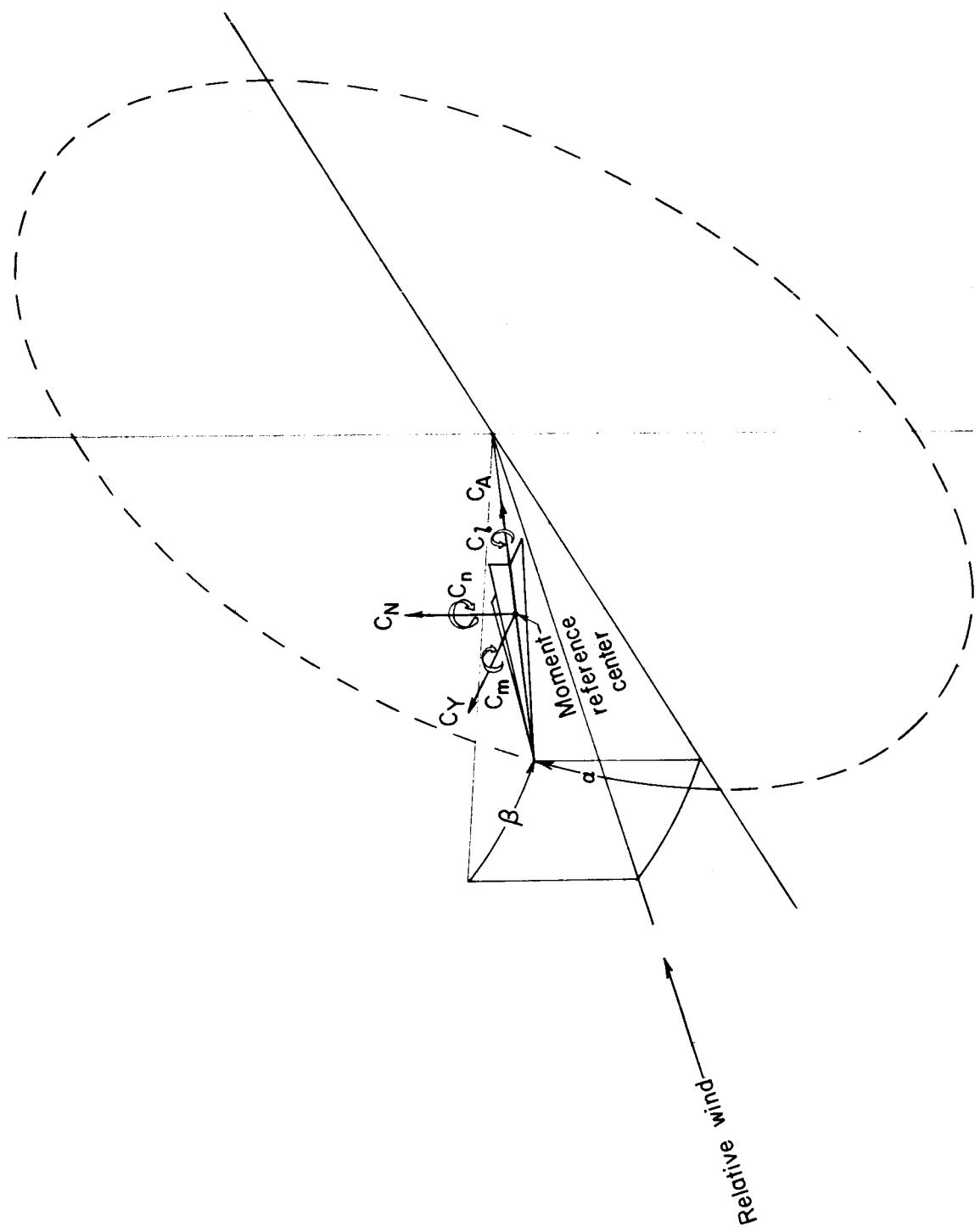


Figure 1.- System of axes. Arrows denote positive directions of forces, moments, and angular measurements.

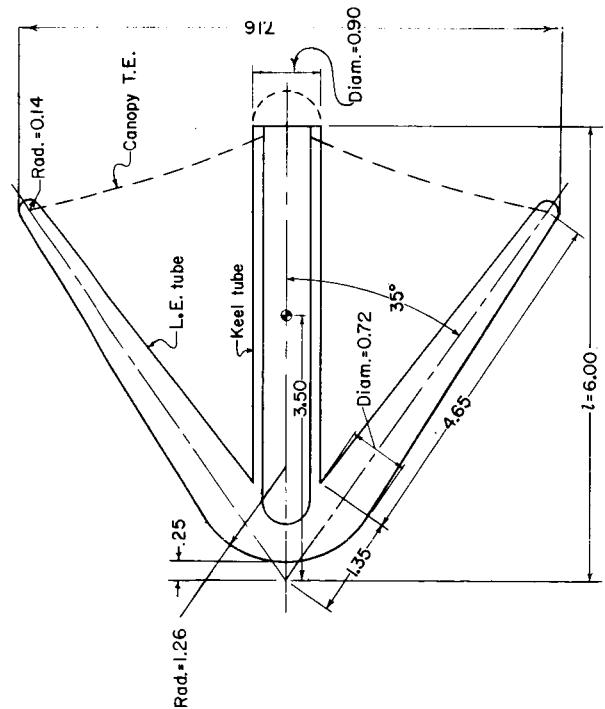
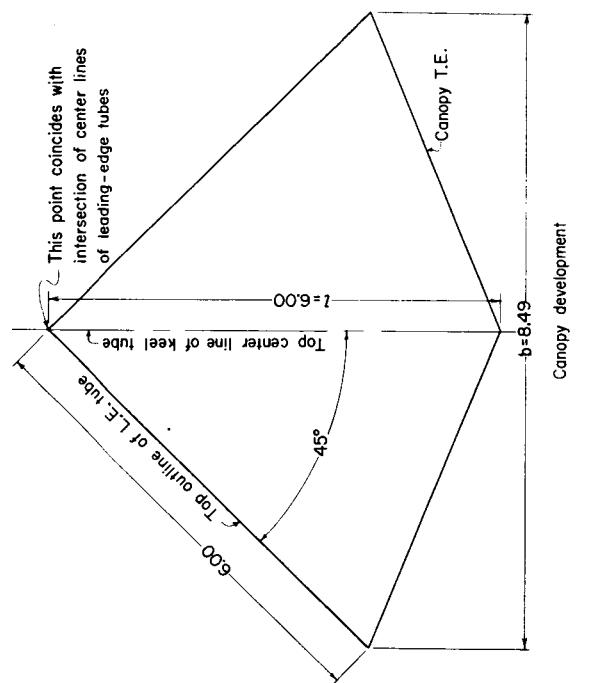
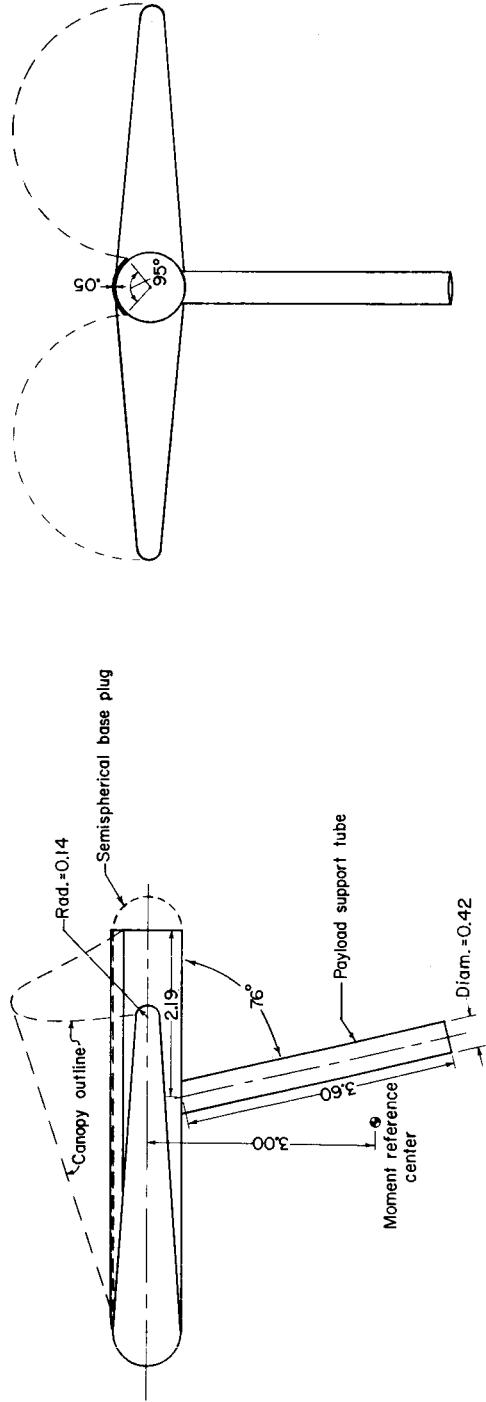


Figure 2.- Details of the paraglider model. All dimensions are in inches unless otherwise noted.

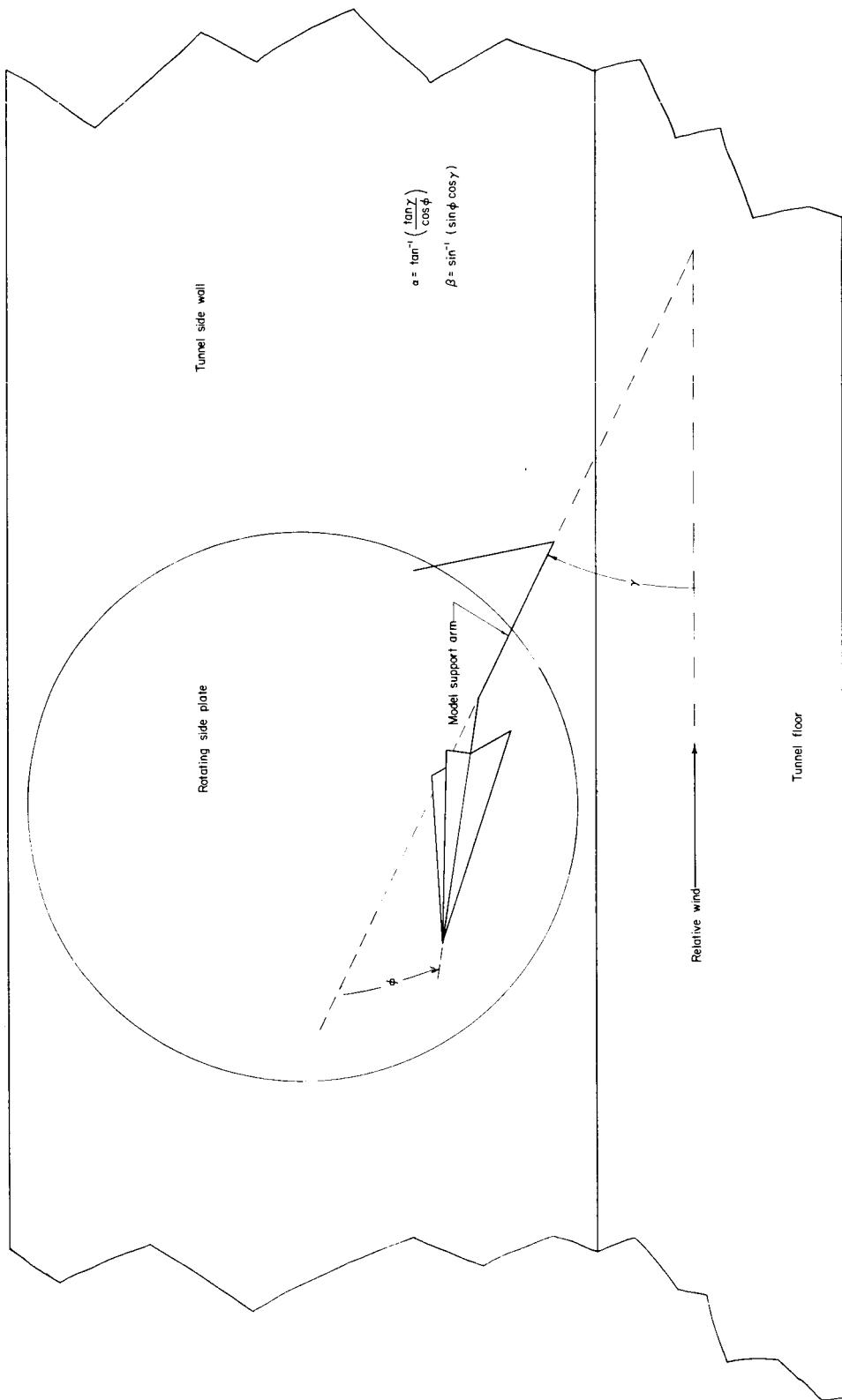


Figure 3.- Schematic diagram of model support system.

L-62-3266

(a) Model facing forward on the support system.

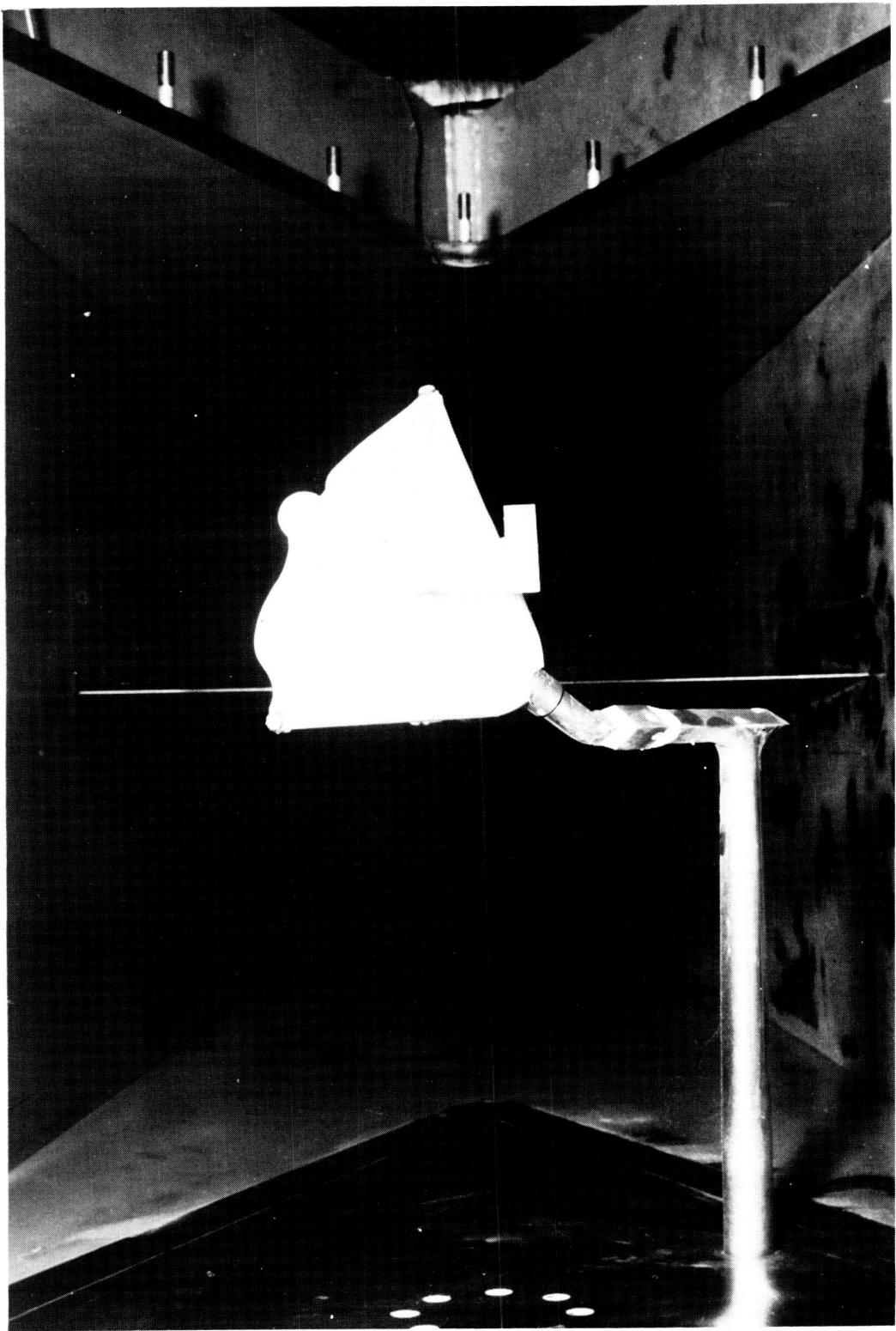
Figure 4.- Model mounted in the 2-foot hypersonic facility at the Langley Research Center.

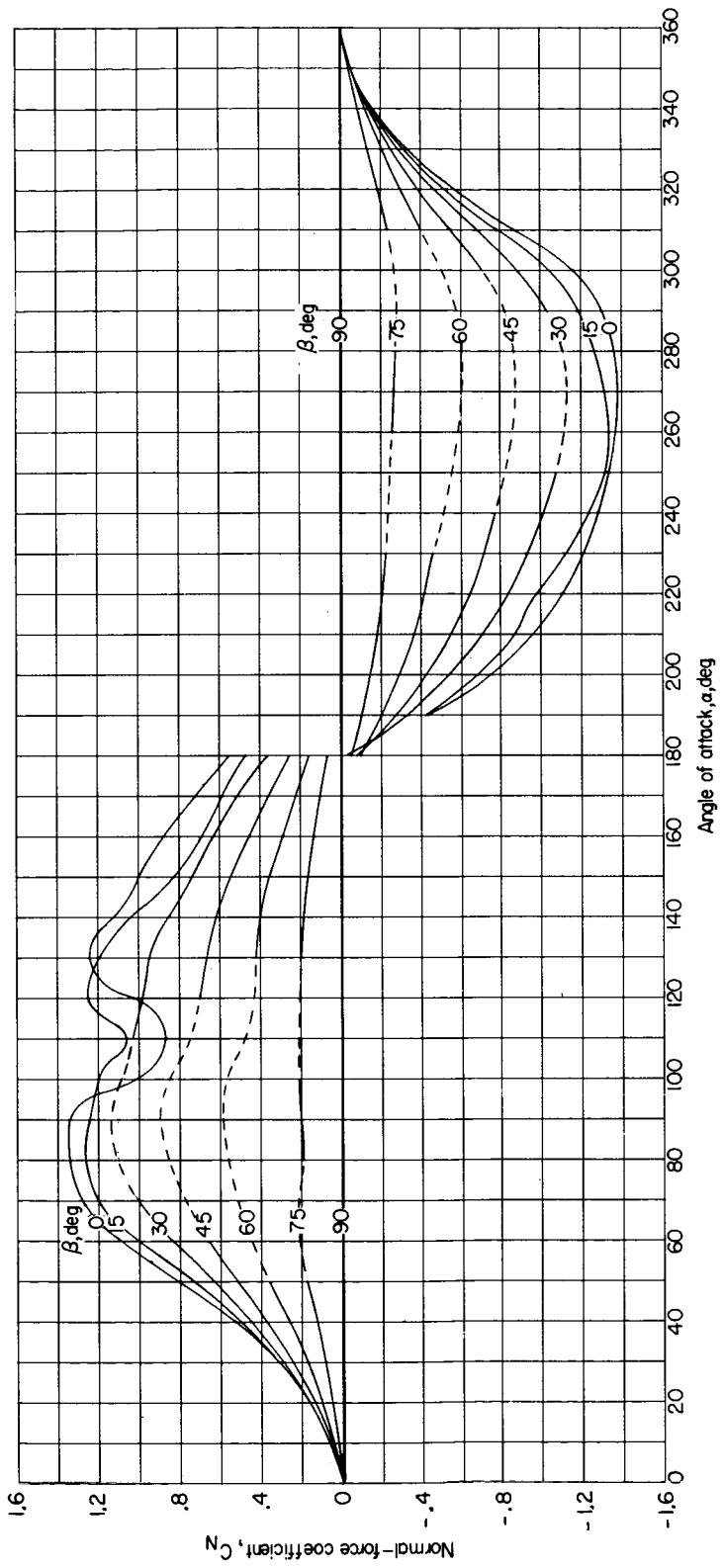


L-62-3056

(b) Model facing rearward on the support system.

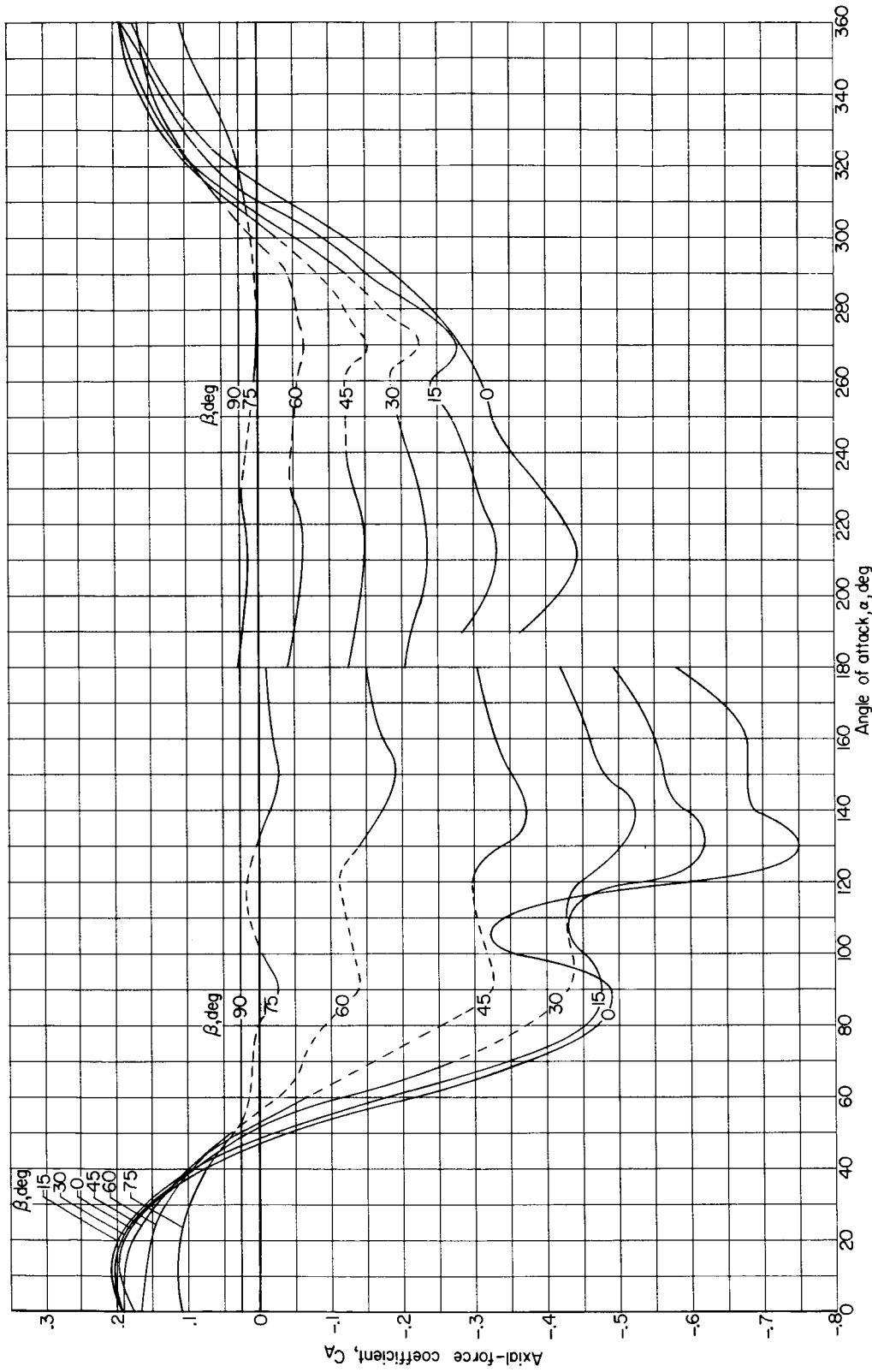
Figure 4.- Concluded.





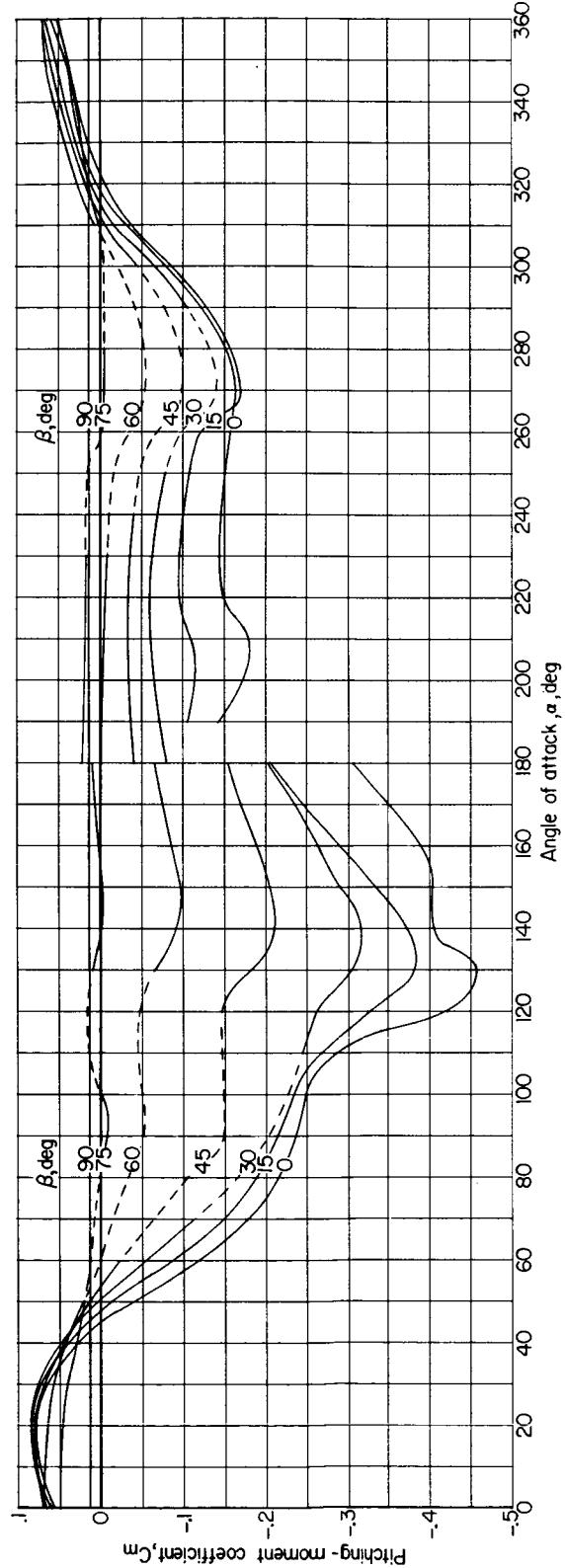
(a) Normal-force coefficient.

Figure 5.- Variation of the aerodynamic coefficients of the paraglider model with angle of attack at constant sideslip angles for a Mach number of 4.5.



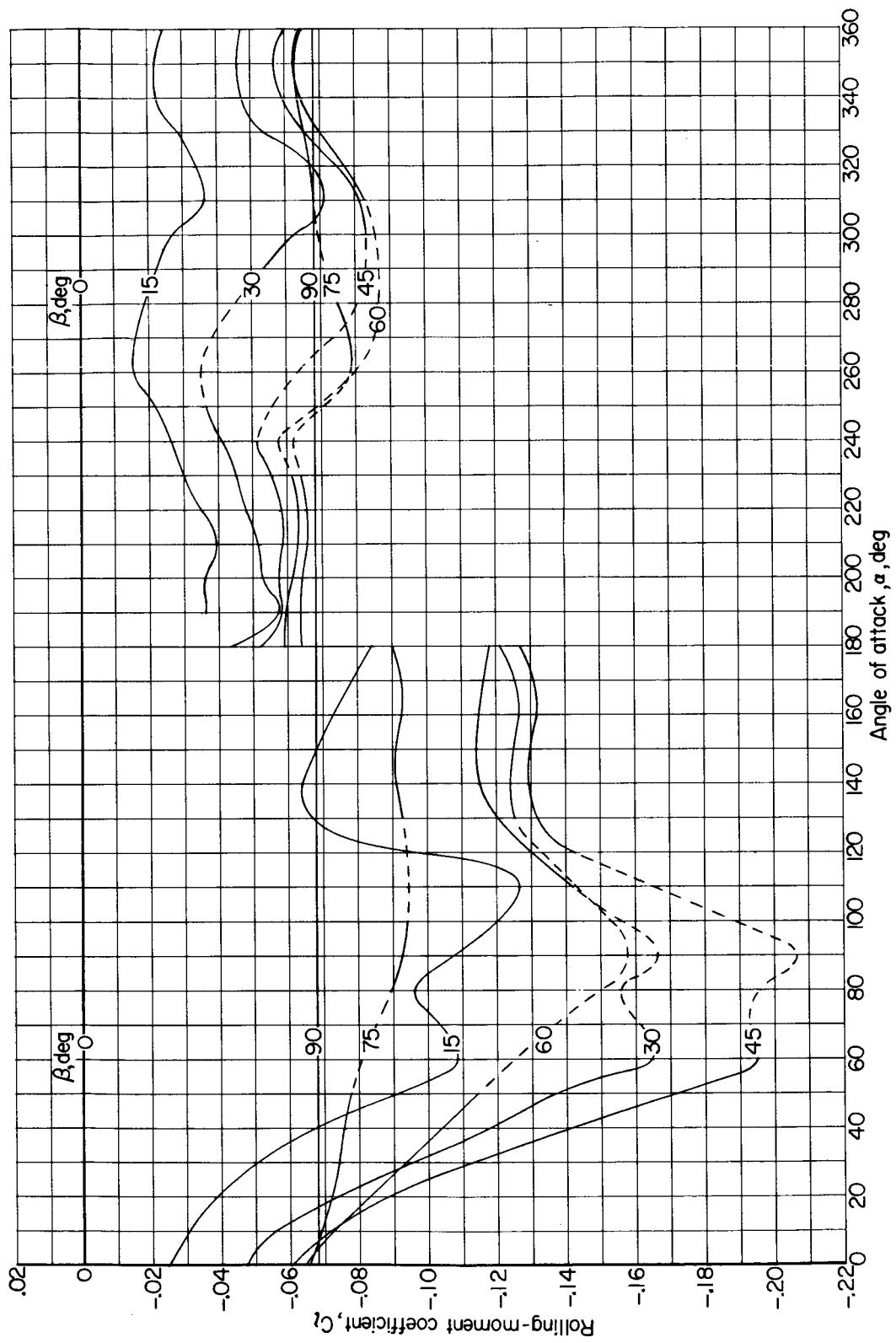
(b) Axial-force coefficient.

Figure 5.- Continued.

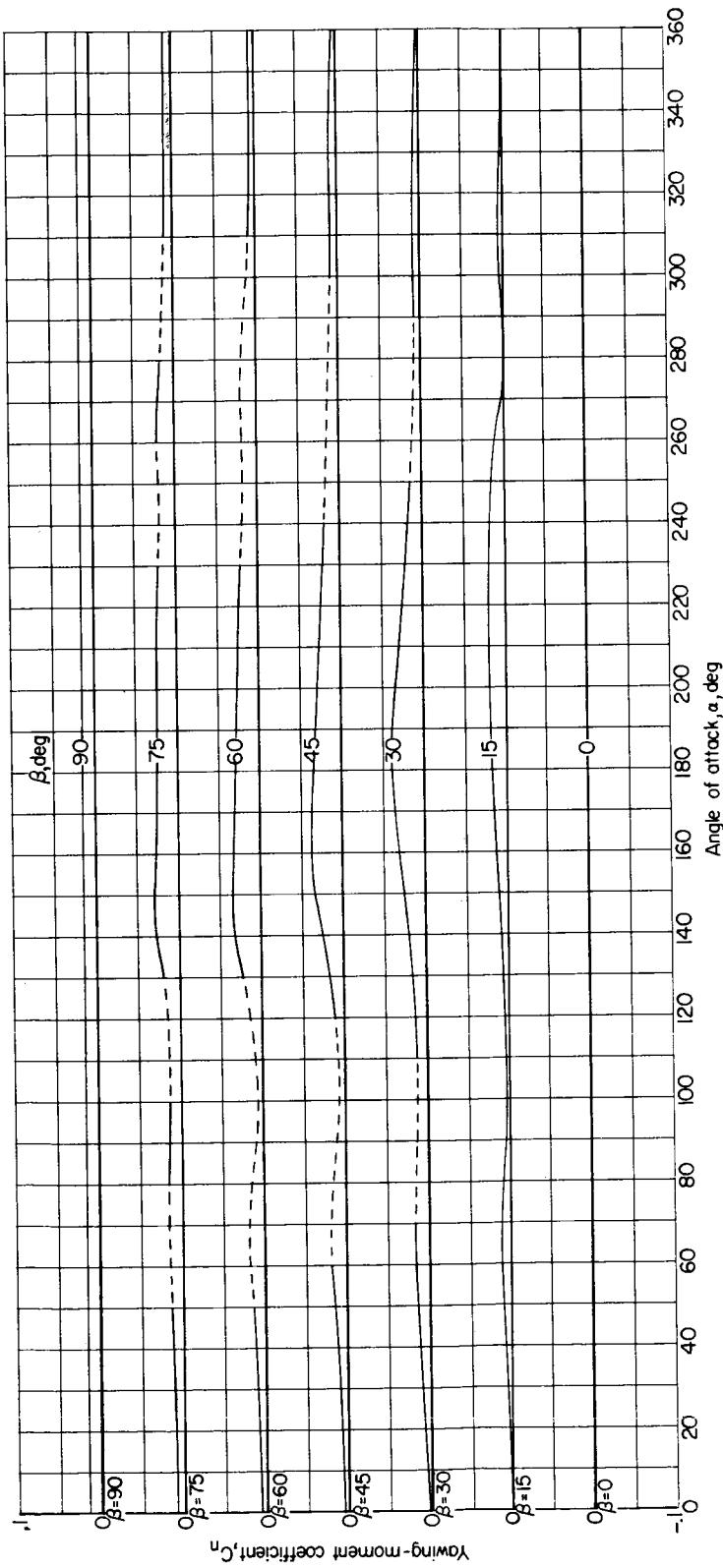


(c) Pitching-moment coefficient.

Figure 5.- Continued.

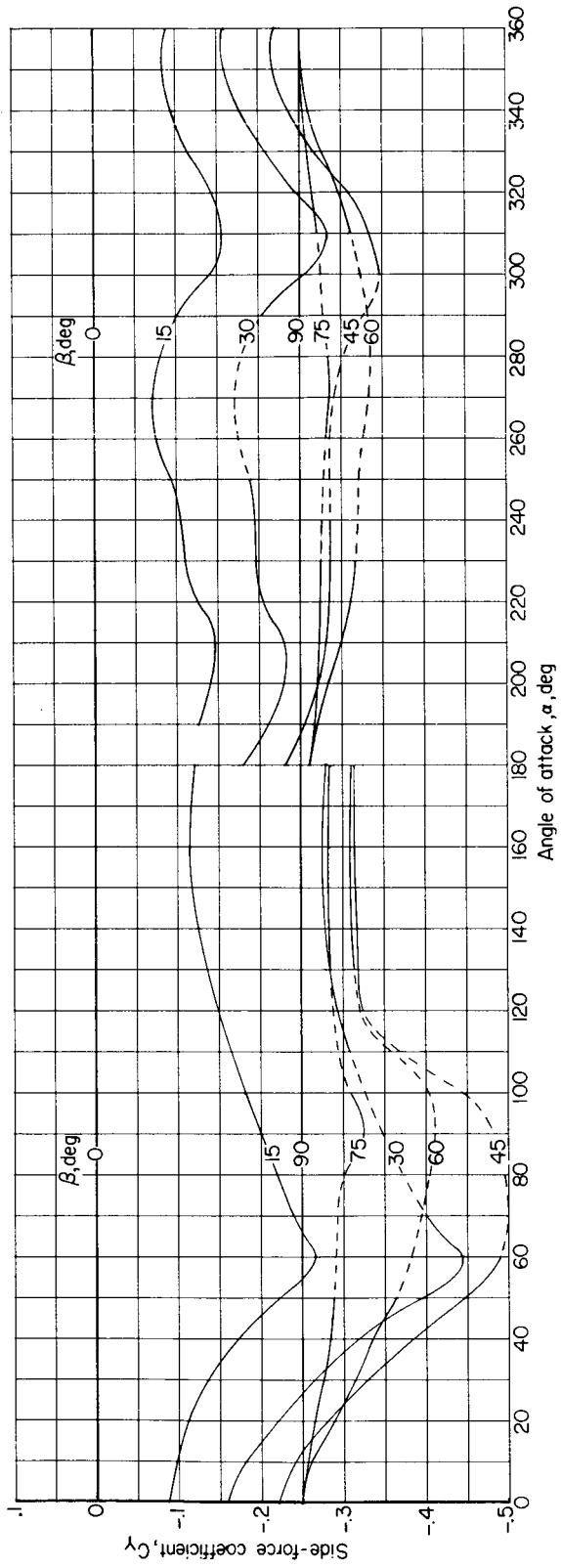


(d) Rolling-moment coefficient.
Figure 5.- Continued.



(e) Yawing-moment coefficient.

Figure 5.- Continued.



(f) Side-force coefficient.

Figure 5.- Concluded.

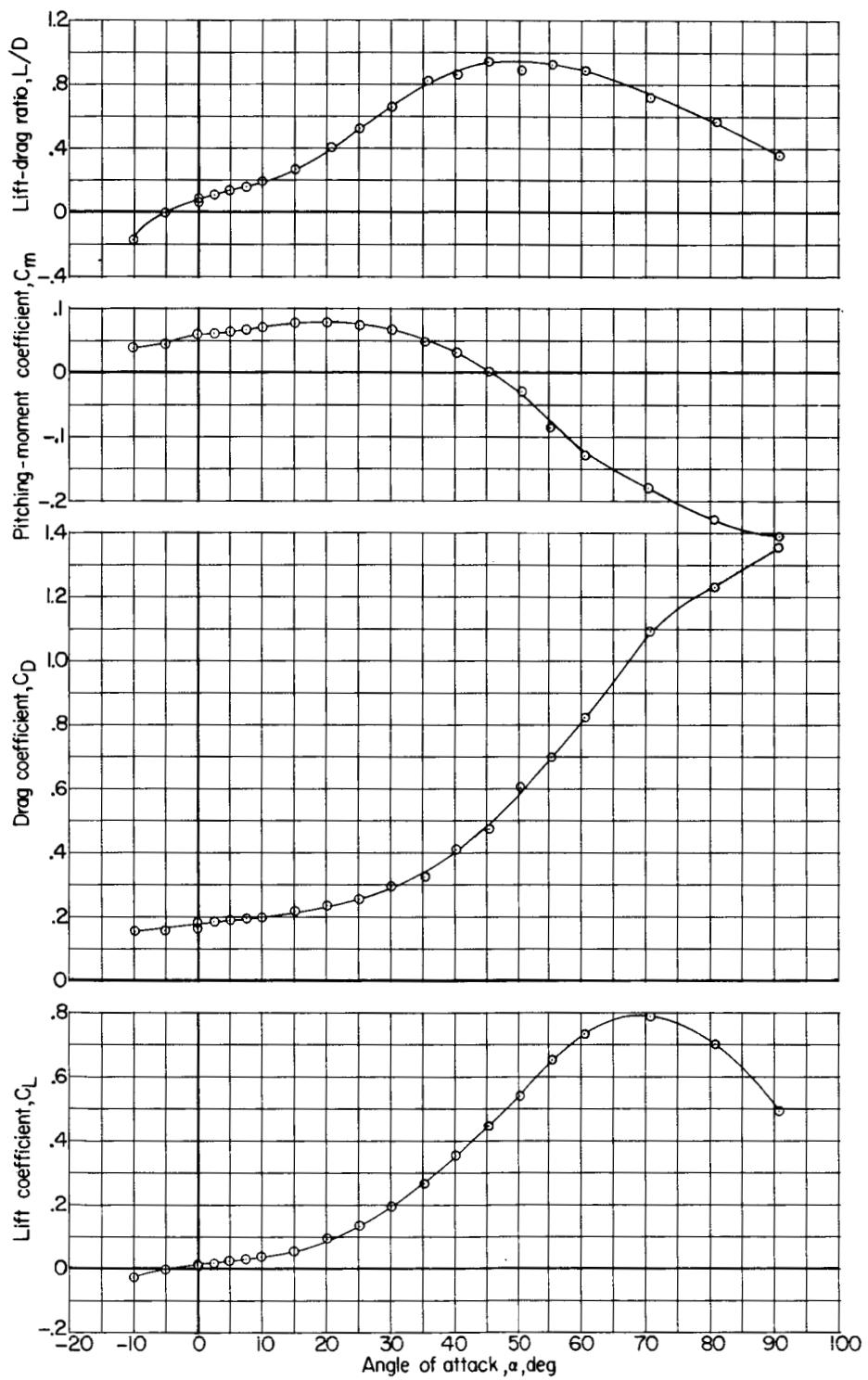


Figure 6.- Longitudinal aerodynamic characteristics of the paraglider model at a Mach number of 4.5.
 $\beta = 0^\circ$.